(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 596 869 A2**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **94101741.0**

(51) Int. Cl.5: **H01B 11/10**, H01B 11/18

(22) Date of filing: **18.04.91**

This application was filed on 04 - 02 - 1994 as a divisional application to the application mentioned under INID code 60.

(30) Priority: **20.04.90 JP 103155/90**
20.04.90 JP 103156/90
20.04.90 JP 103157/90

(43) Date of publication of application:
11.05.94 Bulletin 94/19

(60) Publication number of the earlier application in accordance with Art.76 EPC: **0 452 942**

(84) Designated Contracting States:
DE FR GB

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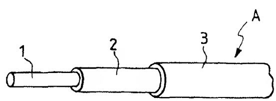
(54) Electromagnetic wave fault prevention cable.

(57) A shield cable, comprising a conductor, a covering insulation layer formed around an outer periphery of said conductor, and an electrically conductive resin layer being disposed around said outer periphery of said conductor and inside said insulation layer, said resin layer having a volume resistivity of 10^{-3} to 10^{5} Ω cm. The electrically conductive resin layer includes vapor phase-growing carbon fiber and graphitized carbon fiber made of said vapor phase-growing carbon fiber, and prevents high frequency interference due to resonance and/or electromagnetic induction.

FIG. 1



EP 0 596 869 A2

BACKGROUND OF THE INVENTION

This invention relates to an electromagnetic interference prevention cable. More specifically, a high-frequency interference prevention and/or electromagnetic wave induction prevention wire is used for electrical connection of an electronic device such as an audio device and an office automatic device.

In conventional electromagnetic and high-frequency circuits, various kinds of shield cables and shield plates have been used in order to prevent malfunction due to noise produced from such circuits.

In the conventional high-frequency interference prevention, a static coupling and an electromagnetic coupling between the wires is interrupted by a shield cable or a shield plate, thereby removing unnecessary oscillation.

However, such method requires a highly technical layout of shield cables and shield plates, and can not actually be achieved easily.

In recent years, computer control for electric devices and electric products has remarkably increased. Electronic circuits of such devices have been highly integrated, and current flowing through elements have been microscopic, and there has arisen a problem that malfunction of the device may occur due to induction between wires of a wiring bundle.

On the other hand, the products have become compact and lightweight, and also the space-saving and lightweight design of the wiring has been strongly desired.

There is also known a shield cable having an electrically-conductive resin.

EP-A 2-0279985 discloses an electrically conductive thermoplastic resin composition which is used for sheilding cables from electromagnetic interference. This composition comprises a thermoplastic resin as a major component and carbon fiber as a minor component, the fiber comprising no more than 8% by volume of the composition. The composition is prepared by dry mixing the ingredients to room temperature in a suitable vessel, extruding them through a die so as to form a molten stream of masticated resin having the fiber distributed therein and are then formed to a desired article. The thus generated electrically conductive resin has a resistivity between 1 and 500 Ω cm.

However, since high electrical conductivity can not be obtained, a practical use of this resin is difficult. Therefore, a metal braid or a metal foil is in practical use. However, the metal braid must have a high braid density, and therefore tends to be heavy and expensive. The metal foil lacks in flexibility, and becomes deteriorated due to corrosion, thus failing to provide sufficient durability. Thus, these problems have been encountered.

Also, there are commercially available shield cables in which metal foil, a metal braid or an electrically-conductive resin is provided, as an electrically-conductive layer, around a conductor insulator or a bundle of wires (Japanese Patent Application Unexamined Publication No. Sho. 64-38909). However, each of all the wires is formed into a shield wire, the wiring bundle has much space loss because of the circular cross-section of the wire. Thus, it is not suited for the space-saving purpose. Further, for connecting the electrically-conductive layer to the earth, a manual operation is required for separating the electrically-conductive layer from the internal conductor, and and therefore the wiring can not be automated.

Further, the type which uses metal as the shielding electrically-conductive layer has a problem that it is heavy and inferior in durability.

SUMMARY OF THE INVENTION

With the above problems in view, it is the object of this invention to provide a high-frequenecy interference prevention wire designed to be used in a high-frequency circuit and in the presence of electromagnetic wave, which eliminates resonance due to interference between wires without the need for any high layout technique, thereby preventing malfunction of the circuit.

This object is achieved by the characterizing features of claim 1.

According to the present invention, there is provided a high-frequency interference prevention cable with an electrically-conductive resin layer having a volume resistivity of 10^{-3} to 10^{5} Ω cm provided between a conductor and a covering insulation layer.

A further embodiment of the invention is indicated in the appended sub-claim.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 and 2 are perspective views of high-frequency interference prevention cables of the present invention, respectively;

Fig. 3 is a view showing a device for measuring an interference prevention effect of the above cables;

Fig. 4 is a graph showing high-frequency interference prevention characteristics of Examples 1 and 2 and Comparative Examples 1 and 2;

Fig. 5 is a view showing principle of the operation of a conventional cable;

Fig. 6 is a view showing principle of the operation of the cable of the present invention;

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The invention will now be described in detail with reference to the drawings.

Fig. 1 shows a high-frequency interference prevention cable A in which an electrically-conductive resin layer 2 is provided around an outer periphery of a conductor 1, and a covering insulation layer 3 is provided around the layer 2.

In a high-frequency interference prevention cable A' shown in Fig.2, an inner insulation layer 4 and a shield layer 5 composed of a metal braid (or metal foil) are provided between a conductor 1 and an electrically-conductive resin layer 2. The shield layer 5 functions to prevent an electromagnetic wave induction.

The electrically-conductive resin layer 2 is made of an electrically-conductive resin having a volume resistivity of 10^{-3} to 10^{5} Ω cm, and preferably 10^{-3} to 10^{2} Ω cm.

The compositions of a matrix, an electrical conductivity-imparting material and the other additives of this electrically-conductive resin are not particularly limited. For example, as the matrix, there can be used a thermoplastic resin such as PE, PP, EVA and PVC, a thermosetting resin such as an epoxy or a phenolic resin, rubber such as silicone rubber, EPDM, CR and fluororubber, or a styrene-type or an olefin-type thermoplastic elastomer or ultraviolet curing resin. One or more of a metal powder, metal fiber, carbon black, PAN-type carbon fiber, pitch-type carbon fiber, vapor phase-growing carbon fiber, graphitized carbon fiber and metal-plated one of these carbon fibers is combined, as the electrical conductivity-imparting material, with the matrix to produce the electrically-conductive resin having a desired volume resistivity. Additives such as a process aid, a filler and a reinforcing agent can be added.

For example, for producing the electrically-conductive resin, 20 to 160 parts by weight of graphitized vapor phase-growing fiber, pulverized into a length of 0.1 to 50 µm, is added to 100 parts by weight of ethylene vinyl acetate resin constituting the matrix, and these are kneaded by a blender such as a pressure kneader, a Henschel mixer and a double-screw mixer, and according to an ordinary procedure, the mixture is extrusion-molded to produce a highly electrically conductive resin having a volume resistivity of 10^{3} to 10^{-3} Ω cm.

The electrically-conductive resin thus obtained is coated onto the conductor 1 or the shield layer 5 (Fig. 2) by a known method such as extrusion. By doing so, advantageous effects of the present invention can be obtained.

Fig.5 shows an electric loop P produced when using a conventional cable a. In order to eliminate this loop, various layouts have been tried as described above. In this Figure, reference character L denotes a reactance of a wire, and reference numeral C denotes a capacitance between the wires and a capacitance between the wire and the earth.

Fig. 6 shows an electric loop P' obtained when using the cable of the present invention having an electrically-conductive resin layer with a volume resistivity of 10^{-3} to 10^{5} Ω cm. R (resistor) is inserted in the closed loop, so that the circuit current is attenuated, thereby reducing the resonance.

Thus, in the high-frequency interference prevention cable of the present invention, R is naturally inserted in the electric loop (resonance circuit) produced when using the conventional cable. Therefore, the resonance due to the wiring in the high-frequency circuit as well as the leakage of the high frequency is prevented.

For preventing the electromagnetic induction, the shield layer is provided on the cable, as described above.

Comparative Example 1

An ordinary wire, having a copper conductor (the cross-sectional area of which was $0.5mm^2$) and an insulation coating (polyvinyl chloride) with an outer diameter of 1.6mm) coated on the conductor, was used as a standard sample.

Example 1

An electrically-conductive resin having a volume resistivity of 10^{0}Ωcm was coated on a copper conductor (the cross-sectional area of which was $0.5mm^2$) to form a 0.4mm-thick resin coating thereon. Then, PVC was coated on the resin coating to form thereon a PVC layer 2.4mm in outer diameter, thereby preparing a high-frequency interference prevention wire (measuring sample) as shown in Fig. 1.

The above standard sample and the above measuring sample were separately set in a central portion of a copper pipe 6 (inner diameter: 10mm; length: 100cm) of a measuring device B shown in Fig. 3, and a high-frequency interference prevention effect (interference with the copper pipe) was measured. In this Figure, reference numeral 7 denotes a FET probe, and reference numeral 8 denotes a spectrum analyzer.

Referring to the measuring method, in the above device B, the components of the frequency, produced in the sample by the induction when an electrical field was applied to the copper pipe, were analyzed by the spectrum analyzer. The standard sample with no shield was first measured, and then the measuring sample was set in the device, and

one end of the shield layer was grounded, and the measuring sample was measured.

The measurement results of the two cables are indicated respectively by a curve a (Comparative Example 1) and a curve b (Example 1) in Fig. 4.

Comparative Example 2

An insulation coating (PVC) having an outer diameter of 1.6 Ø mm was formed on a copper conductor having a cross-sectional area of 0.5 mm^2, and a metal braid was provided on the insulation coating to form a shield structure (outer diameter: 2.1 ϕ mm) thereon. Then, a covering insulation layer (PVC) was formed on the shield structure to prepare a shield cable having an outer diameter of 2.9 ϕ mm.

Example 2

An electrically-conductive resin was coated on the shield braid of Comparative Example 2 to form thereon an electrically-conductive resin layer having a thickness of 0.4mm and a volume resistivity of 10^0 Ω cm, thereby preparing a high-frequency interference prevention cable as shown in Fig.2

A high-frequency interference prevention effect was measured with respect to the above two cables in the same manner as described above. The results thereof are indicated by a curve c (Comparative Example 2) and a curve d (Example 2) in Fig. 4.

As is clear from Fig. 4, with respect to Comparative Example 1 (curve a), the cable resonated with the copper pipe, and a large interference due to induction is recognized. However, with respect to Example 1 (curve b), it will be appreciated that this interference is greatly reduced.

Similarly, in Comparative Example 2 (curve c), better electromagnetic wave induction prevention effect than that of Comparative Example 1 (curve a) is obtained, but the cable resonated with the copper pipe, and a large interference is recognized. In Example 2 (curve d), the interference is greatly reduced.

As described above, by using the high-frequency interference prevention cable of the present invention, the interference due to the resonance in the high-frequency circuit can be prevented, and the use of the conventional shield plate and the difficulty of the layout are omitted, thereby achieving the space-saving.

Further, by addition of the shield layer, the electromagnetic wave induction can be prevented at the same time, thereby eliminating malfunction of the circuit.

If the electrical conductivity-imparting material of the electrically-conductive resin is of the carbon type, the cable is lightweight, and excellent corrosion resistance is achieved.

Claims

1. A shield cable comprising:
   a conductor (1);
   a covering insulation layer (3) formed around an outer periphery of said conductor (1), and
   an electrically conductive resin layer (2) which is provided around said outer periphery of said conductor (1) inside said insulation layer (3),
   characterized in that
   said electrically conductive resin layer (2) has a volume resistivity of 10^{-3} to 10^5 Ωcm and includes vapor phase-growing carbon fiber and graphitized carbon fiber made of said vapor phase-growing carbon fiber, said electrically conductive resin layer (2) preventing high-frequency interference due to resonance and/or electromagnetic induction.

2. A shield cable as claimed in claim 1,
   characterized in that
   an inner insulation layer (4) and a shield layer (5) are provided between said conductor (1) and said electrically conductive resin layer (2), said shield layer (5) being composed of a metal braid or a metal foil.

FIG. 1

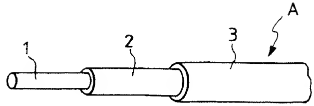


FIG. 2

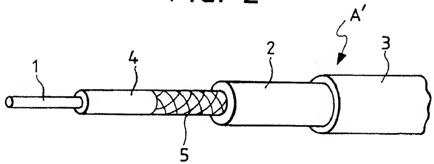


FIG. 3

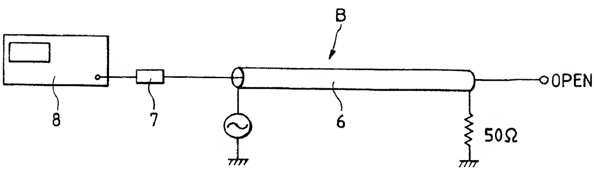


FIG. 4

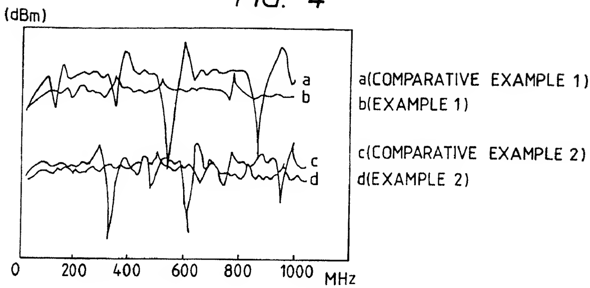


FIG. 5 PRIOR ART

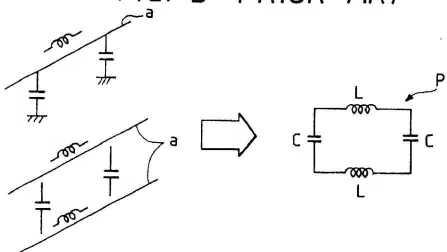


FIG. 6